CURRENT PRACTICES AND RECENT ADVANCES IN PRESCRIBED BURNING

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ABSTRACT

Fire is a natural and important part of southern forest ecosystems. Prescribed burning is currently used by forest managers to protect stands from wildfire, prepare sites for regeneration, improve wildlife habitat, control disease and improve forage for grazing animals. Researchers continue to increase our knowledge of prescribed burning with studies of its effects on soil properties, water quality, vegetation and wildlife. Other recent advances include new burning techniques such as aerial ignition, guidelines for smoke management and prediction of fire behavior and effects. This paper discusses the major current uses of prescribed burning in forest management and several recent advances in prescribed burning technology.

INTRODUCTION

Prescribed burning in the South originated as a tradition of woodsburning by both Indians and early settlers. Fire has always been a natural and important ecological force helping to shape and structure southern forests (Komarek, 1974). Plants and plant communities evolved under a regime of periodic lightning-induced fire prior to the advent of prehistoric man. With the arrival of early Indians to the Southeast some 10 to 20 thousand years ago, fire became a more frequent occurrence. The use of low-intensity surface fires at frequent intervals, coupled with an occasional conflagration during times of drought, produced open grasslands and forests free from underbrush on many mesic and xeric sites. Plant communities evolved which not only tolerated fire, but actually required it for their continued existence.

In the early 1900's, the last virgin pine forests were harvested leaving the South with over 92 million acres of cutover lands. As long as these areas were annually burned, they produced a grazing resource and were so used. However, frequent fires precluded pine regeneration which most of the large absentee landowners desired. It was not long before most southern states followed the federal land management agencies in banning all fire. By eliminating fire, foresters inadvertently promoted successional trends that lead to forests totally different than those of previous millenia.

Controversy concerning the role of prescribed fire in forestry caused heated debates in the early decades of the 20th century. Gradually, the importance of the proper use of fire became established. Ellen Long (1889) was among the first to recognize that stands of longleaf pine were replaced by hardwoods when fire was removed from the ecosystem. In the early 1900's, H. H. Chapman of Yale University had distinguished between wildfire, prescribed fire and woodsburning and advocated the use of prescribed fire in longleaf pine management (Pyne 1982). The wildlife biologist Stoddard published a major study on the importance of prescribed fire in the management of bobwhite quail in 1931. During the next several decades some disasterous consequences of fire exclusion policies were realized as a series of destructive wildfires ravaged the South. The vigorous broadleaf understory shaded out the grazing resource, competed very effectively with the developing pine overstory and contributed to the already hazardous buildup of fuels. The use of low-intensity fire was again, although reluctantly at first, allowed as increasing numbers of foresters became convinced of the potential if not actual need for this tool to improve range and wildlife habitat, to manipulate plant succession and most importantly to reduce the buildup of fuels that under more severe burning conditions could support conflagrations.

Today, most foresters recognize the importance of prescribed fire as a forest management tool. Over the past 15 years, the area of forest land in the South that was prescribed burned annually increased from 2 million acres (Hough, 1973) to over 5 million acres (USDA Forest Service, 1985). However, it remains a tool which is often misused and misunderstood and which has the potential to be self-restrictive if the practice is abused. Much remains to be learned about its uses and management in a more urbanized Southern environment.

CURRENT PRACTICES

Prescribed fire, i.e., fire to accomplish specific management objectives, is used for many purposes. Currently, fuel reduction is the major objective of most prescribed fires, especially in the vast pineries of the Coastal Plain. Without periodic burning, an understory of hardwoods, shrubs and vines rapidly develops and, when draped with pine straw, becomes a highly dangerous rough. In less than a decade, this rough can support intense wildfires capable of destroying the overstory and doing extensive damage to property.

More than 50 percent of the nation's wildfire acreage occurs in the South. Much of this acreage is in young pine plantations where damage is often severe. Periodic prescribed fires would drastically reduce the potential of wildfire damage on the nearly 61 million acres of pine in the South. Burning programs are well-established on most lands managed by forest industry and federal and state governments, but many nonindustrial private forest landowners have neither the expertise nor capital to use prescribed fire. In addition, fire is seldom prescribed in young pine stands where wildfire damage potential is most severe (Wade, 1985). Even though there is no feasible alternative to prescribed burning for temporarilly "fireproofing" timber stands, few guidelines for burning young pine stands exist. Moreover, the number of ideal burning days and experienced personnel have often been inadequate to get the job done.

Fire can be used to prepare seedbeds or sites for planting. Fires used to prepare seedbeds for natural seeding are generally of low-intensity and are normally conducted in early fall prior to seedfall and the harvest cut. Complete mineral soil exposure is not necessary for successful natural regeneration of pine stands. Removal of the upper layer of duff will often allow sufficient germination to establish a new stand. Low-intensity burns have been used effectively in the Coastal Plain (Lotti, 1961) and Piedmont (Van Lear et al., 1983) to regenerate loblolly pine by clearcutting with seed-in-place. Similar types of burning are recommended prior to the reproduction cut in the seedtree method or any cut in the shelterwood method (Baker and Balmer, 1983). To avoid damage to overstory trees, it is often necessary to begin with one or more winter burns to reduce fuel loadings before summer fires are used to control the developing hardwoods.

Fire intensity is greater for site preparation burns prior to planting since logging slash provides heavy fuel loads. Site preparation burns are generally scheduled the first summer after logging so the sites can be planted the following winter. During the early summer months, sprouting from hardwood stumps after burning is less vigorous (Langdon, 1981). However, for hardwood management intense fires can promote good quality sprouts by forcing development from the ground line or below, rather than higher on the stump (Roth and Sleeth, 1939; Roth and Hepting, 1942). Site preparation burning in the Southern Appalachians has increased the plantable area by about 15 percent by top-killing laurel and rhododendron thickets. Although these plants resprout, their subsequent growth is not rapid enough to outcompete the planted pines.

Hardwood understories can be manipulated by varying the frequency and timing of fire (Lotti, 1961; Lewis and Harshbarger, 1976; Langdon, 1981). Low-intensity prescribed fires are generally effective in top-killing hardwood stems less than 3 inches in diameter (Ferguson, 1961). Summer fires tend to be more effective in killing hardwoods than winter fires. Root stocks of small hardwoods generally sprout following low-intensity fires, although sprouting vigor varies by species and the season and frequency of burning. Summer or winter burns at 3-5 year intervals do little to control the number of small hardwoods but will effectively control their size (Langdon, 1981). Annual winter fires will not eliminate understory hardwood stems, even if repeated for decades, but annual or biennial summer fires will eventually remove virtually all small understory hardwoods from the stand.

By controlling the hardwood understory with frequent prescribed fires, the pine types upon which southern forestry industry now depends can be maintained. Unfortunately, the needed manpower and equipment to burn the necessary acreage on non-industrial lands is not presently available. The pine resources will continue to decline in the South until hardwood understories are controlled by more frequent burning.

Even after southern pine stands are established, the intentional use of fire can continue to play a silvicultural role. It has the potential to thin overly dense pine stands (McNab, 1977; Nickles et al. 1981). Brownspot needle blight in longleaf pine seedlings can be effectively controlled during the grass stage with periodic burning. Burning also encourages rapid height growth out of the grass stage (Boyer and Peterson, 1983). Prior to harvest, fire can facilitate cruising and marking operations and decrease logging costs by improving accessability to stands.

Prescribed fire is used to modify wildlife habitat by regulating the stature and composition of the understory (Lyon et al., 1978; Harlow and Van Lear, 1981; Wood, 1981). Prescribed fire improves habitat by increasing browse (Lay, 1957; Lewis and Harshbarger, 1976; Stransky and Harlow, 1981), by promoting legumes and herbaceous vegetation (Stoddard, 1931; Clewell, 1966; Landgon, 1981), by stimulating germination of seed stored in the forest floor and by setting back succession to create or maintain cover requirements (Stoddard, 1931; Waldrop et al., 1985). Knowledge of the habitat requirements of animal species to be featured in management, particularly those of threatened or endangered species, will dictate the role of fire in accomplishing management goals. Because southern wildlife evolved under a regime of frequent fire, it should not be surprising that prescribed burning is beneficial to or tolerated by most wildlife species. A thorough treatise on the effects of prescribed fire on southern wildlife is provided in a recent symposium proceedings (Wood, 1981).

Prescribed fire also improves forage for domestic grazing animals by increasing the palatability, quality, quantity and availability of grasses and forbs (Komarek, 1974). Annual winter or biennial summer burning was recommended by Lewis and Harshbarger (1976) to produce the highest forage yields for cattle. Frequent burning creates an open, park-like appearance in stands which is esthetically pleasing. The number and diversity of annual and biennial flowering plants in frequently burned stands is dramatically increased, thereby improving the appearance of the area and perhaps its ecological stability.

RECENT ADVANCES

The remainder of this paper briefly describes some of the more important recent advances pertaining to the intentional use of fire and its effects on various ecosystem components.

Burning Techniques

To meet prescribed burning objectives, weather conditions must be within specified ranges. The fact that these weather conditions occur on a limited number of days is the major reason more acreage is not burned. Managers must therefore take advantage of the relatively few days when fuel, weather and smoke dispersal conditions are acceptable. The development of aerial ignition systems provides the methodology to dramatically increase the acreage treated with prescription fire during a given burning period (Lait and Muraro, 1977; Sain, 1979). A major advantage of aerial ignition is that large areas can be burned quickly under ideal weather and fuel conditions. Both the ping-pong ball system (plastic containers filled with potassium permanganate) (Gnann, 1985) and the helitorch system (gelled gasoline dropped from a drip torch suspended under a helicopter) (Stevens, 1985) have been used successfully in the South.

Johansen (1985) suggested that the helitorch system was best suited for site preparation burning. The gelled gasoline is long-burning and adheres well to all fuels. The gell can penetrate into piled debris that would otherwise be difficult to burn. Johansen also stated that the ping-pong ball system was best suited for burning in existing stands. With the latter system, the operator has better control of the placement of spots and resulting intensities are generally lower because much of the area will be burned by flank fires. On the other hand, spacing between spots within a line is generally close and difficult to control with a helitorch resulting in quick lateral merger and subsequent progression downwind as a headfire.

Because fire intensity is greater with spot-fire techniques (more merging flame fronts) than with conventional line backfires, burning with aerial ignition systems may need to be done under moister conditions to avoid stand or site damage (Wade, 1985). Baughman (1985) reported that when fire lines and spots within fire lines are very close together, fires burn out rapidly before they gain much heat or speed. This method was successful as a fuel reduction burn in loblolly pine plantations that were only 15 to 20 feet tall (6 to 8 years old). Johansen (1984) found that slash pine stands with less than 3 year's rough can be burned using square ignition grid patterns without excessive crown scorch. Aerial ignition of prescribed fires promises to be a valuable tool, but continued testing is needed to determine the best burning method(s) to obtain desired management objectives.

The use of prescribed fire in the Southern Appalachians is an advance in itself. Prescribed fire is used on the Sumter National Forest in the mountains of South Carolina to improve wildlife habitat, reduce fuel hazard and prepare sites for planting. It has only been in the last 5 to 6 years that fire has been used for management purposes on steep mountain terrain in the South. As the demand for softwood timber increases, many sites on sloping terrain will be converted from hardwoods to pine and prescribed burning will be used. Therefore, a better understanding is needed of how to burn on slopes and what the effects will be to the site.

Site preparation burns in the Southern Appalachians are currently conducted in advance of stand conversion. Burning of the lush green vegetation in the summer following clearcutting is readily accomplished by felling residual whips and culls after spring leaf out, followed by a month or so of curing with burning in June, July or August.[1/] This procedure allows site preparation burns to be done within days after soaking rains when the lower forest floor and soil are still moist, thereby keeping potential soil damage to a minimum. The number of burning days, which is often limiting, is increased because of the presence of cured fuels. In addition, adjacent uncut stands are less at risk because fine fuels in these stands are at a higher moisture content than in the clearcut area. The firing technique is generally to backfire off the ridges followed by strip headfires from below. Pine seedlings are planted the next winter. Where labor is not available or too expensive for felling residuals, herbicides can accomplish the objective of producing cured fuels for more effective burning.

On areas where logging debris and residual trees must be mechanically removed, recent research demonstrates that piling is more effective than windrowing because of more rapid combustion and shorter periods of smoke production (Johansen, 1981). This finding is important from a smoke management standpoint since windrows may smoke for days and produce dangerous pockets of low visibility.

Effects on Soil and Water Properties

Properly conducted low-intensity prescribed fires have not been found to have significant adverse effects on chemical or physical properties of Coastal Plain soils. McKee (1982) showed that long-term prescribed burning on sand and silt loam soils had no deleterious effects on soil organic matter and increased available phosphorus in the mineral soil. Soil nitrogen was increased by annual winter burning. Calcium increased in the mineral soil with burning treatments, rather than being immobilized in the forest floor as on unburned plots. McKee suggested that prescribed burning may slow the weathering process, thereby helping to maintain soil productivity, since leaching of cations by organic acids from the decomposing forest floor is reduced.

Soil erosion is not accelerated by low-intensity prescribed fires on the slopes of the Piedmont (Douglass and Van Lear, 1983). Low to moderate intensity fires can be prescribed to only consume part of the forest floor; thus, infiltration of precipitation is not significantly impaired and overland flow is avoided. Cushwa et al. (1971) did not detect significant soil movement in established gullies following moderately intense backfires in mature loblolly pine stands of the South Carolina Piedmont. These studies support observations of early explorers (e.g. Bartram, 1791) that Piedmont streams flowed clear despite frequent burning by Indians.

High intensity site preparation burns conducted under conditions of high fuel loads and low soil moisture can completely expose mineral soil and accelerate soil erosion in steep terrain. However, a recent study in the mountains of South Carolina indicated that high-intensity, site-preparation burns, as previously described, do not significantly increase soil erosion over clearcutting alone (Danielovich, 1986). Apparently the unburned portion of the forest floor, unconsumed slash materials, and the intact root mat hold the mineral soil in place until the site is reclaimed by vegetation which vigorously invades burned clearcuts.

There is little doubt that prescribed fire, if not judiciously planned and executed, can cause significant increases in soil erosion. However, when applied under the proper fuel, weather and soil conditions, prescribed burning is not accompanied by increased erosion even in steep mountain terrain. Much more remains to be learned about the effects of fire on soils. Effects of plant ash on soil biological processes and the interactive effects of plant ash and soil heating in relation to vegetative response are not well understood (Raison, 1979). Effects of prescribed fire on nutrient budgets of forest ecosystems need further study.

Effects of prescribed fire on water quality have recently been studied in the Piedmont. Douglass and Van Lear (1983) monitored water quality of ephemeral streams following two low-intensity prescribed fires in Piedmont loblolly pine stands and detected no significant effects on suspended sediment or nutrient concentrations. Richter et al. (1982) failed to detect any major impact on stormflow or soil solution nutrient levels in response to low-intensity prescribed fire in the Coastal Plain. No studies in the South have examined the effects of high-intensity slash burning on streamflow nutrient levels, although Neary and Currier (1982) found no increase in nutrient levels in Appalachian stream draining watersheds burned by an intense wildfire.

Effects on Vegetation

Periodic low-intensity fires at intervals of several years favor woody species which are more fire-resistant than their competitors. A series of periodic fires prior to harvest of mature hardwood stands may increase the number of oaks in the advance regeneration pool (Little, 1974), an important consideration in the reestablishment of stands with a large oak component. Several studies indicate that oak seedlings resist root kill by fire better than their competitors, thereby giving oak an ecological advantage (Swan, 1970; Niering et al., 1970; Langdon, 1981). Advance regeneration in oaks of Central Tennessee was doubled by both annual (for 6 years) and periodic (at 5-year intervals) pre-harvest prescribed fires (Thor and Nichols, 1974). Biennial summer burns in pine stands of South Carolina caused less mortality to oaks than in competing hardwood species (Waldrop et al.[2/]). However, a single low-intensity prescribed fire in a mature hardwood stand had only a slight positive effect on increasing the relative position of oak regeneration in the mountains of South Carolina and Georgia (Teuke and Van Lear, 1982). More research is needed to identify the role of fire and provide the technology for using prescribed fire to encourage oak regeneration.

There have been several recent studies that assess pine survival and growth following various levels of fire damage. Waldrop and Van Lear (1984) reported no growth loss in pole-sized loblolly pine after fires of low to moderate intensity. When high-intensity fires caused complete crown scorch, however, 20 percent of the codominant individuals were killed. Villarrubia and Chambers (1978) found little mortality in loblolly pines whose crowns were completely scorched except for the needles adjacent to buds. Trees with a slight amount of crown scorch had significantly greater radial growth than unscorched trees, a fact attributed to the death of lower noncontributing limbs. Johansen (1984) reported significant losses in radial growth in trees with crown scorch approaching 100 percent. Even though these trees survived, many had no spring or summer radial growth the year after a dormant season burn.

Effects on Wildlife

It has recently been reported that the endangered red-cockaded woodpecker prefers to nest and forage in pine stands where a hardwood midstory is essentially absent (Jackson et al., 1977; Van Balen and Doerr, 1978). Pine stands with well developed hardwood midstories are favored habitat for pileated woodpeckers and red-bellied woodpeckers, both of which may compete with red-cockaded woodpeckers for cavity trees (Jackson, 1979). Periodic prescribed fire may be the only practical tool for preventing hardwoods from growing into the midstory. However, special care must be taken with prescribed fires around cavity trees. The resin or pitch flow on cavity trees readily ignites and can result in the destruction of the cavity or death of the tree (Conner, 1981). Connor and Locke (1979) recommended frequent burning to prevent excessive fuel loading. Research which provides methods of predicting fire intensity would be useful for planning fires that would protect cavity trees.

Increased sprouting has long been recognized as a wildlife benefit associated with prescribed burning. It is a relatively recent finding, however, that fruit production of understory plants, such as gallberry, huckleberry and blueberry, is reduced if burning is done at intervals shorter than three years (Johnson and Landers, 1978; Stransky and Halls, 1980). These understory plants need a recovery period of about two years before production of soft mast equals preburned conditions.

Smoke Management

Air pollution caused by the smoke of prescribed fires is of increasing concern to foresters. Carbon dioxide, water vapor, gaseous hydrocarbons, carbon monoxide and nitrous oxides are released to the atmosphere in smoke, but the major pollutant from fire is particulate matter which impairs visibility and contains several compounds known to affect human health (McMahon, 1985). On a national level, prescribed burning accounts for less than 3 percent of the total emissions of particulates, carbon monoxide and hydrocarbons (Chi et al., 1979). On a local level, however, reduced visibility near highways and airports is of major concern.

Because of the serious nature of the effects of prescribed fire on air quality and its concomitant value as an essential forest management tool, smoke management guidelines have been developed by the USDA Forest Service to reduce the atmospheric impacts of prescribed fire (USDA Forest Service, 1976). Their 'Combustion Processes in Wildland Fuels' project has studied the chemical and physical properties of smoke, factors determining smoke dispersal and the relationship of fire and fuel characteristics to emissions characteristics. Study results from each of these topics have been reported in several publications which are described by McMahon (1985). Their results should provide basic information that will improve guidelines for smoke management. At present, all federal agencies and all but three southern states have voluntary or mandatory smoke-related restrictions on prescribed burning (Mobley, 1985) and these three exhibit an increased awareness of potential smoke management problems.

Prediction of Fire Behavior and Effects

When any prescribed fire is planned, the ability to predict fire behavior or intensity as well as the effects of that fire is extremely important. With better predictive capabilities, forest managers may be able to expand the burning season by identifying burn days that would otherwise be considered unsuitable. In addition, managers may be able to burn stands that were previously considered too risky because, for example, they are too young or have high fuel loadings. Numerous qualitative methods of predicting fire damage have been tested but with limited success (Wade, 1985). The best method for predicting fire behavior and damage remains to rely upon the judgement of personnel with considerable experience in prescribed burning.

Wade (1985) suggested a major problem in relating fire behavior to effects is the lack of a reliable measure or rating system for fire behavior. One of the easiest fire behavior parameters to estimate is flame length. It is therefore the most commonly used means of estimating fire intensity in the field. However, Johnson (1982) found inconsistencies between measured flame lengths and those predicted by fire intensity models. Wade (1985) suggested that these differences were due to innaccurate estimates of flame length.

The USDA Forest Service has developed several models which integrate many factors in attempting to give accurate fire behavior predictions. The 1978 National Fire Danger Rating System (NFDRS) uses a combination of fuel and weather conditions to provide fire danger indices for large geographic areas. Although attempts have been made to use this system for planning prescribed fires, Shepherd (1985) suggested that results are unreliable when used for individual fires, particularly in the South where understory brush fuels are heavy. Wade (1985) stated that the indices and components of the NFDRS must be adjusted to make it work under southern fuel and weather conditions but that it then may become an acceptable analog of fire behavior and damage.

The BEHAVE system (Rothermel, 1983; Burgan and Rothermel, 1984) was developed to be used in conjunction with the NFDRS to predict the behavior of individual prescribed fires. This system allows the use of customized fuel models rather than the NFDRS models to more accurately approximate on-site fuel conditions (Shepherd, 1985).

CONCLUSIONS

The practice of prescribed burning is an important tool in the management of southern ecosystems. Virtually all of these ecosystems evolved under a regime of frequent low-intensity fires, occassional high-intensity stand replacement fires, or a combination of the two. Therefore, most southern forests benefit from or tolerate periodic prescribed burning with little adverse impact to water, soil, wildlife and timber resources.

Currently, the major use of prescribed burning in the South is to reduce fuel levels to protect forests from wildfires. Prescribed burning is also used to prepare seedbeds and sites for seeding and planting, improve habitat for certain wildlife species, control disease and improve forage for grazing animals. When conducted properly, prescribed fires can be used to achieve each of these objectives with little or no damage to overstory pines.

Prescribed burning research has increased our knowledge of burning techniques and fire effects over the past several decades. Recent studies have shown how large areas of forest land can be burned quickly with aerial ignition. Experienced practictioners are now using fire in steep terrain in the Piedmont and mountains. We also have a better understanding of how burning affects soil fertility, erosion and water quality. Current research projects are assessing the relationship between fire damage and growth rates as well as developing techniques for burning young stands. The potential of prescribed fire to encourage advance regeneration of oak has recently received renewed attention. Other studies have shown that prescribed fire benefits the red-cockaded woodpecker, an endangered species. Perhaps, the greatest threat to the continued use of prescribed fire is a public outcry against the practice because of poor smoke management, but guidelines for smoke management are now available.

Although much progress is being made regarding the uses and effects of prescribed fire, much remains to be learned before site specific effects of fire and smoke behavior can be adequately predicted. Proper planning and execution of fires using evolving technology will help to obtain the desired results with minimal adverse effects.

NOTES

1/Personal communication with Jim Abercrombie, Assistant District Ranger, Andrew Pickens Ranger District, Sumter National Forest, South Carolina.

2/Waldrop, T.A., D.H. Van Lear, and W.R. Harms. Long-term studies of prescribed burning on the Santee Experimental Forest. Manuscript in preparation.

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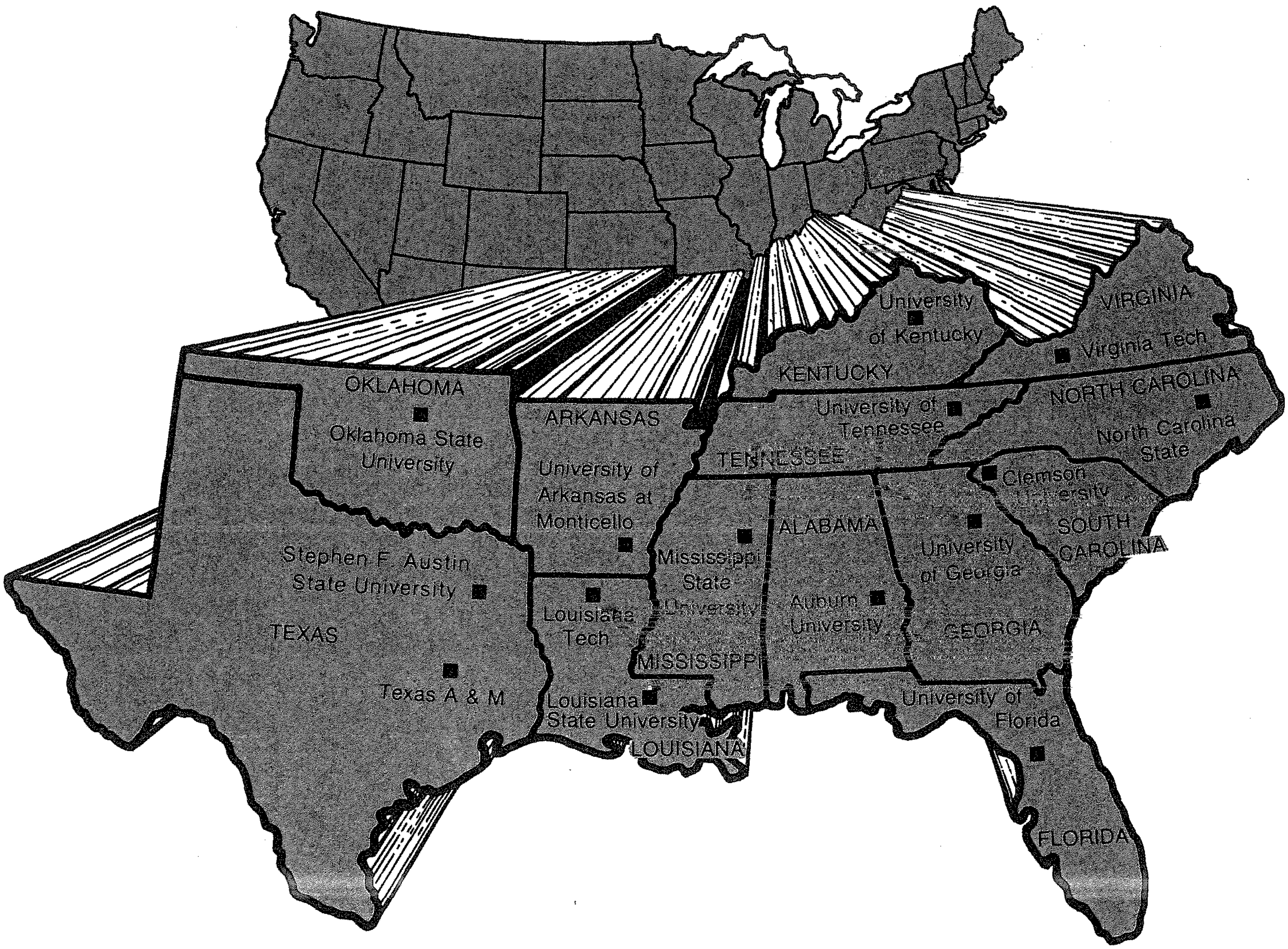

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